Chapter 4: Electricity: Magnetic and Heating Effects

Exercises — Keep the Curiosity Alive

Q1 Fill in the blanks:

(i) The solution used in a Voltaic cell is called _____.

(ii) A current carrying coil behaves like a _____ .

SOLUTION

(i) The solution used in a Voltaic cell is called an electrolyte.

The electrolyte is the conducting liquid that allows electric current to flow due to the movement of ions. In a simple Voltaic cell it can be a salt solution or an acidic liquid such as lemon juice; Volta himself first used saltwater-soaked paper between two different metals.

(ii) A current carrying coil behaves like a magnet (electromagnet).

When electric current passes through a coil of wire, it creates a magnetic field around the coil. The coil acts like a bar magnet with a North pole at one end and a South pole at the other. This is called an electromagnet.

Answer: (i) electrolyte; (ii) magnet (electromagnet)

Q2 Choose the correct option:

(i) Dry cells are less portable compared to Voltaic cells. (True/False)

(ii) A coil becomes an electromagnet only when electric current flows through it. (True/False)

(iii) An electromagnet, using a single cell, attracts more iron paper clips than the same electromagnet with a battery of 2 cells. (True/False)

SOLUTION

(i) FALSE.

Dry cells are MORE portable than Voltaic cells. A Voltaic cell uses a liquid electrolyte (dilute acid) which can spill, making it bulky and hazardous to carry. Dry cells use a paste electrolyte, are sealed, compact, and easy to carry.

(ii) TRUE.

A coil becomes an electromagnet only when electric current flows through it. The magnetic field is produced solely by the moving electric charges (current). Without current, the coil has no magnetic properties.

(iii) FALSE.

A battery of 2 cells provides more voltage, which drives a larger current through the coil. More current → stronger magnetic field → the electromagnet attracts MORE iron paper clips, not fewer. A single cell produces a weaker magnet than a 2-cell battery.

Answer: (i) False; (ii) True; (iii) False

Q3 An electric current flows through a nichrome wire for a short time.
(i) The wire becomes warm.
(ii) A magnetic compass placed below the wire is deflected.
Choose the correct option:
(a) Only (i) is correct
(b) Only (ii) is correct
(c) Both (i) and (ii) are correct
(d) Both (i) and (ii) are not correct

SOLUTION

Any current-carrying conductor produces two simultaneous effects:

Statement (i) — The wire becomes warm: TRUE.
Electric current flowing through nichrome (which has high electrical resistance) converts electrical energy into heat energy. This is the heating effect of electric current. All current-carrying wires produce heat; nichrome produces especially significant heat due to its high resistivity.

Statement (ii) — A magnetic compass placed below the wire is deflected: TRUE.
Any current-carrying conductor produces a magnetic field around it (Oersted's discovery). This magnetic field exerts a force on the compass needle and deflects it. The compass deflects even for a straight wire, not just a coil.

Both effects occur simultaneously whenever current flows.
The correct option is (c) — Both (i) and (ii) are correct.

Answer: (c) Both (i) and (ii) are correct

Q4 Match the items in Column A with those in Column B.

Column A:

(i) Voltaic cell

(ii) Electric iron

(iii) Nichrome wire

(iv) Electromagnet

Column B:

(a) Best suited for electric heater

(b) Works on magnetic effect of electric current

(c) Works on heating effect of electric current

(d) Generates electricity by chemical reactions

SOLUTION

(i) Voltaic cell → (d) Generates electricity by chemical reactions.
A Voltaic cell produces electric current through chemical reactions between zinc and copper electrodes in an acidic electrolyte. It is a source of electrical energy, not a user of it.

(ii) Electric iron → (c) Works on heating effect of electric current.
An electric iron has a coil of resistance wire that heats up when current flows through it ($P = I^2R$). The heat is transferred to the iron's base plate to press clothes. This is the heating effect of electric current.

(iii) Nichrome wire → (a) Best suited for electric heater.
Nichrome (nickel-chromium alloy) has high electrical resistivity and a very high melting point, so it can glow red-hot without melting or oxidising. This makes it the ideal material for the heating element in electric heaters, toasters, and irons.

(iv) Electromagnet → (b) Works on magnetic effect of electric current.
An electromagnet is a coil of wire (often wound around an iron core) that produces a magnetic field when current flows through it. Its operation is based entirely on the magnetic effect of electric current.

Answer: (i)→(d); (ii)→(c); (iii)→(a); (iv)→(b)

Q5 Nichrome wire is commonly used in electrical heating devices because it
(i) is a good conductor of electricity.
(ii) generates more heat for a given current.
(iii) is cheaper than copper.
(iv) is an insulator of electricity.

SOLUTION

Evaluating each option:

(i) is a good conductor of electricity — CORRECT.
Nichrome is a metallic alloy and conducts electricity, allowing current to flow through it to produce heat. If it were a perfect insulator, no current would flow and no heat would be produced.

(ii) generates more heat for a given current — CORRECT.
Nichrome has much higher electrical resistivity than copper or aluminium. Using $P = I^2R$, a higher resistance R means more heat (P) is produced for the same current (I). This is exactly why nichrome is preferred over copper wires for heating devices — copper has low resistance and wastes little energy as heat, which suits wiring but not heaters.
Additionally, nichrome has a very high melting point (~1400°C) and does not oxidise at high temperatures, making it safe for continuous use.

(iii) is cheaper than copper — INCORRECT.
Nichrome (a nickel-chromium alloy) is more expensive than copper. It is chosen for its performance properties, not its cost.

(iv) is an insulator of electricity — INCORRECT.
Nichrome is a conductor (a resistive conductor). Insulators cannot carry current and cannot produce heat via the heating effect.

The correct options are (i) and (ii).

Answer: (i) and (ii) are correct: nichrome is a conductor with high resistivity, generating more heat for a given current

Q6 Electric heating devices (like an electric heater or a stove) are often considered more convenient than traditional heating methods (like burning firewood or charcoal). Give reason(s) to support this statement considering societal impact.

SOLUTION

Electric heating devices are more convenient and have better societal impact for the following reasons:

1. No air pollution indoors: Burning firewood or charcoal releases smoke, carbon monoxide, and particulate matter inside homes, causing serious respiratory diseases. Electric heaters produce no smoke or combustion gases, improving indoor air quality.

2. No deforestation: Burning firewood requires cutting trees, which leads to deforestation and environmental damage. Electric devices use electrical energy and do not require wood, helping protect forests.

3. Precise and adjustable temperature control: Electric heaters can be switched on/off instantly and adjusted to exact temperatures. Traditional methods are difficult to control and take time to start or stop.

4. Safety: Open fires from firewood or charcoal pose burn hazards and fire risks. Electric heaters have enclosed heating elements, reducing the risk of accidental fires and burns.

5. Clean and smoke-free cooking/heating: Electric stoves keep the kitchen and living spaces free from soot and ash, improving hygiene and reducing cleaning effort.

6. Convenience and time-saving: Electric devices can be switched on immediately and reach working temperature quickly, saving time compared to lighting and managing a wood or charcoal fire.

7. Health benefits for women and children: In many households, women and children are most exposed to indoor cooking smoke. Switching to electric heating significantly reduces their health risks from smoke inhalation.

Answer: Electric heating devices are more convenient due to: no indoor air pollution, no deforestation, precise temperature control, greater safety, cleanliness, and health benefits — especially compared to firewood/charcoal that produce smoke and require forest resources.

Q7 Look at the Fig. 4.4a. If the compass placed near the coil deflects: (i) Draw an arrow on the diagram to show the path of the electric current. (ii) Explain why the compass needle moves when current flows. (iii) Predict what would happen to the deflection if you reverse the battery terminals.

SOLUTION

Fig. 4.4a shows an electromagnet coil with ends labelled A and B, connected to a battery. A magnetic compass is placed near end A of the coil.

(i) Direction of electric current:

In Fig. 4.4a, the coil (ends labelled A and B) is connected to a cell below it, and the compass is placed near end A. Conventional current flows out of the positive (+) terminal of the cell, through the connecting wires, all the way around the coil windings, and back into the negative (−) terminal.

Arrow direction on the diagram: draw the arrow along the connecting wires and around the coil in one continuous direction — starting at the + terminal of the cell, through the external circuit and the coil turns, and returning to the − terminal. (Which physical end, A or B, the current enters first depends on how the student's own cell is wired to the coil; the arrow simply follows the + → external circuit → − path consistently.)

(ii) Why the compass needle moves when current flows:

An electric current flowing through a conductor creates a magnetic field around it (this is the magnetic effect of electric current, first discovered by Hans Christian Oersted).

When the current flows through the coil, it generates a magnetic field. The coil behaves like a bar magnet with a North pole at one end and a South pole at the other end.

A magnetic compass needle is itself a small magnet. When placed near the current-carrying coil, the magnetic field of the coil exerts a force on the compass needle.

The compass needle aligns itself along the direction of the combined magnetic field (Earth's field + coil's field), causing it to deflect away from its usual north-south position.

(iii) Effect of reversing the battery terminals:

If the battery terminals are reversed, the direction of current through the coil reverses.

This causes the magnetic poles at the two ends of the coil to swap — the end that

was a North pole becomes a South pole, and vice versa.
As a result, the compass needle near end A will deflect in the OPPOSITE direction compared to before.
The magnitude of deflection will remain approximately the same (same current strength), but the needle will point in the opposite direction.

Answer: (i) Arrow follows conventional current from + terminal → external circuit → coil → − terminal. (ii) Current creates a magnetic field around the coil (Oersted's discovery); the coil acts as a magnet and deflects the compass needle. (iii) Reversing terminals reverses current direction → magnetic poles swap → compass needle deflects in the opposite direction.

Q8 Suppose Sumana forgets to move the switch of her lifting electromagnet model to OFF position (in introduction story). After some time, the iron nail no longer picks up the iron paper clips, but the wire wrapped around the iron nail is still warm. Why did the lifting electromagnet stop lifting the clips? Give possible reasons.

SOLUTION

The electromagnet stopped lifting iron paper clips because the magnetic strength of the electromagnet decreased. There are several possible reasons:

Reason 1 — Battery (cell) got discharged:
The most likely reason is that the battery drained over time. As the battery discharges, it provides less current. Since the magnetic field strength of an electromagnet depends on the amount of current flowing (stronger current → stronger magnet), a weaker current means a weaker magnetic field — too weak to lift the clips.

Reason 2 — Increased wire resistance due to heating:
The wire wrapped around the nail heats up (which is why it is still warm). As the wire heats up, its electrical resistance increases. Higher resistance → less current for the same battery voltage → weaker magnetic field.

Reason 3 — Loose connections:
Prolonged heating can loosen wire connections in the circuit, increasing contact resistance or creating partial breaks, reducing the current and therefore the magnetic strength.

Why is the wire still warm despite the weak magnetic field?
The heating effect ($P = I^2R$) requires only a small current to produce noticeable

warmth, especially in a coil of wire with moderate resistance. Even a weak current from a nearly-discharged battery can still warm the wire, even though this same weak current is insufficient to create a strong enough magnetic field to pick up clips.

Heating effect and magnetic effect both depend on current, but picking up clips requires the magnetic field to exceed a threshold, whereas warmth is perceivable even at much lower current levels.

Answer: The electromagnet stopped lifting clips because the battery discharged (less current → weaker magnetic field). Other possible reasons: increased wire resistance due to heating (reduces current), or loose connections. The wire stays warm because even a small residual current produces heat ($P = I^2R$), but this weak current is insufficient to sustain the magnetic field needed to lift clips.

Q9 In Fig. 4.12, in which case the LED will glow when the switch is closed?
(a) Iron nail + Copper strip + Lemon juice
(b) Iron nail + Copper strip + Pure water

SOLUTION

From Fig. 4.12, both circuits have an LED, a switch, an iron nail electrode, and a copper strip electrode. The difference is in the liquid between the electrodes:
Circuit (a): Lemon juice as the liquid.
Circuit (b): Pure water as the liquid.

Analysis of circuit (a) — Lemon juice:
Lemon juice is acidic (contains citric acid). It is an electrolyte — it contains ions (H^+ and citrate ions) that can carry electric charge. When the switch is closed, the ions in the lemon juice move between the electrodes, allowing electric current to flow through the circuit. The current is sufficient to light the LED.
The LED in circuit (a) WILL GLOW.

Analysis of circuit (b) — Pure water:
Pure (distilled) water is a very poor conductor of electricity. It contains virtually no free ions. Without ions to carry the charge, current cannot flow through the liquid, so the circuit is effectively broken.
The LED in circuit (b) will NOT GLOW.

Conclusion: The LED will glow only in circuit (a), where lemon juice (an electrolyte) completes the circuit by conducting electricity.

Answer: The LED will glow in case (a) — lemon juice is an electrolyte (acidic, contains ions) that conducts electricity. Pure water in case (b) is a non-conductor (no free ions), so the LED will not glow.

Q10 Neha keeps the coil exactly the same as in Activity 4.4 but slides the iron nail out, leaving only the coiled wire. Will the coil still deflect the compass? If yes, will the deflection be more or less than before?

SOLUTION

Yes, the coil of wire will STILL deflect the compass needle even after the iron nail is removed.

Reason — Why the compass still deflects:
The magnetic field around a current-carrying coil is produced by the electric current flowing through the wire, NOT by the iron core. Any current-carrying conductor creates a magnetic field (Oersted's discovery). A coil of wire concentrates this magnetic field, and it still behaves like a magnet when current flows, regardless of whether there is an iron nail inside.

Reason — Why the deflection will be LESS than before:
The iron nail (iron core) acts as a ferromagnetic material. When placed inside the coil, it gets magnetised by the coil's magnetic field. The magnetised iron nail then ADDS its own magnetic field to the coil's field, making the combined magnetic field much stronger.
Without the iron nail, only the coil's magnetic field remains — which is weaker than the combined field.
Therefore, the compass needle will still deflect, but by a smaller angle than when the iron nail was inside the coil.

Summary: Compass deflects → YES. Deflection compared to before → LESS (because the iron core amplifies the magnetic field; without it, the field is weaker).

Answer: Yes, the coil will still deflect the compass — a current-carrying coil alone creates a magnetic field. But the deflection will be LESS than before, because the iron nail (core) amplifies the magnetic field; without it, the field is weaker.

Q11 We have four coils, of similar shape and size, made up from iron, copper, aluminium, and nichrome as shown in Fig. 4.13. When current is passed through the coils, compass needles placed near the coils will show deflection.
(i) Only in circuit (a)
(ii) Only in circuits (a) and (b)
(iii) Only in circuits (a), (b), and (c)
(iv) In all four circuits

SOLUTION

Fig. 4.13 shows four coils: (a) Iron, (b) Copper, (c) Aluminium, (d) Nichrome.

Key principle: A compass deflects near a current-carrying coil because the current produces a magnetic field. This happens for ANY conductor carrying current — the magnetic effect of current depends on current flowing, not on the specific material of the conductor.

Checking each material:

Circuit (a) — Iron coil: Iron is a good conductor of electricity. Current flows → magnetic field produced → compass DEFLECTS.

Circuit (b) — Copper coil: Copper is an excellent conductor. Current flows easily → magnetic field produced → compass DEFLECTS.

Circuit (c) — Aluminium coil: Aluminium is a good conductor. Current flows → magnetic field produced → compass DEFLECTS.

Circuit (d) — Nichrome coil: Nichrome is a resistive conductor (it has high resistance compared to copper, but it IS a conductor — it is a metallic alloy). Current does flow through it (that is why it heats up in electric heaters!). Current flows → magnetic field produced → compass DEFLECTS.

All four materials (iron, copper, aluminium, nichrome) are conductors. When the circuit is completed, current flows through all four coils, and each produces a magnetic field that deflects the compass needle.

The correct option is (iv) — In all four circuits.

Answer: (iv) In all four circuits — all four materials (iron, copper, aluminium, nichrome) are electrical conductors; current flows through each coil producing a magnetic field that deflects the compass needle.